Appendix E

STAFF INVESTIGATION REPORT
January 5, 2009

SUBJECT: Trees Grow Into and Short Out ComEd 345,000 Volt Transmission Line

SUMMARY: On July 6, 9, and 15, 2008, ComEd experienced instantaneous circuit breaker trips and successful recloses[1] on its Kincaid-Latham-Blue Mound electric transmission line. ComEd discovered three[2] cottonwood trees in a grove of perhaps one hundred trees directly under the line, growing into and shorting out (momentarily) the 345,000 volt ("345-kV") electric transmission line on those occasions.

ComEd records[3] indicate that contractors failed to write proper vegetation management plans, failed to cut trees, failed to report work not completed, failed to file timely reports, and failed to perform quality assurance inspections. ComEd failed to notice and take action on those contractor failures. In Staff's opinion, ComEd devoted too few management personnel to transmission system vegetation management for the available work load. That meant ComEd had to depend on contractor reports to monitor the transmission vegetation management program and had no effective independent field verification program of its own. As late as July 7, 2008, ComEd had assured the Commission Staff that it was trimming trees on a five-year maintenance cycle and conducting annual foot inspections of ALL transmission facilities.

Staff believes that ComEd needs to reassess the level of commitment and resources necessary to effectively manage its transmission vegetation management programs. Further, the failures that led to this incident may have similar roots in vegetation management programs for ComEd's distribution system requiring reassessments in distribution vegetation management.

WHY TRANSMMISSION LINE VEGETATION MANAGEMENT IS IMPORTANT: The Federal Energy Regulatory Commission, in a September 7, 2004, report, noted the consequences of vegetation management failures on transmission lines.

> On August 14, 2003, an electric power blackout affected large portions of the Northeast and Midwest United States and Ontario, Canada. President George W. Bush and Prime Minister Jean Chrétien established a joint U.S.-Canada Power System Outage Task Force (Task Force) to investigate the causes of the blackout and how to reduce the possibility of future outages. On April 5, 2004, the Task Force issued a Final Blackout

[1] Open and reclosed Automatically (OA/CA)
[2] Page 8, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[3] ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.

Report[4] stating that one of the four primary causes of the blackout was inadequate vegetation management (tree pruning and removal).

As described in the Blackout Solutions[5] report, "A perfect storm of near-peak demand, computer errors, obsolete equipment, inadequate training and miscommunication resulted in cascading … power outages …" lead to the 2003 event. While Chapter 4 of the Blackout Report lists the full spectrum of causes that contributed to the 2003 event the tipping point was reached with the failure of three 345-kV lines. In describing the 345-kV line failures that initiated the cascade of failures that directly caused the 2003 blackout the Final Blackout Report authors stated, "These line trips were not random. Rather, each was the result of a contact between a line and a tree that had grown so tall that, over a period of years, it encroached into the required clearance height for the line."[6] Similarities existed between ComEd's 345-kV OA/CA operations on July 6, 9, and 15, 2008, and the Ohio 345-kV line failures in 2003. First, the 345-kV lines in both circumstances were loaded well below emergency ratings. Second, the events were caused by tree contacts that should never have occurred. Fortunately, no other simultaneous critical transmission system failures occurred during ComEd's three incidents, and under those conditions, ComEd's transmission protection system design, ratings, and maintenance practices[7] were adequate to prevent a cascading blackout event from occurring last July in Illinois like that in Ohio in August 2003.[8]

THE COMED EVENT: The trees did not short out[9] ComEd's line only once, but three times. Attached to this Staff report is ComEd's root cause analysis report of the incident. ComEd's report contains detailed descriptions of the events that led to ComEd's discovery of trees growing into its 345-kV transmission line. ComEd's

[4] U.S.-Canada Power System Outage Task Force, Final Report on the August 14th Blackout in the United States and Canada: Causes and Recommendations (April 2004) (Final Blackout Report).

[5] Page 1, Blackout Solutions, June 2004, Final Report of the Special Task Force on the Condition and Future of the Illinois Energy Infrastructure.

[6] Page 57, Chapter 4, U.S.-Canada Power System Outage Task Force, Final Report on the August 14th Blackout in the United States and Canada: Causes and Recommendations (April 2004) (Final Blackout Report).

[7] Immediately following the August 2003 blackout the Commission directed Liberty Consulting Group to conduct a focused review of ComEd's transmission system relays and circuit breakers as this was the type of equipment that should limit the size and scope of transmission outages and lessen the risk of an uncontrolled cascading event in Illinois. On December 16, 2003, Liberty Consulting Group completed a "Report on a Focused Review of Commonwealth Edison's Transmission System Protection" for the Commission. Liberty found that ComEd was doing many things right to minimize the chance of a system-wide cascading outage like what had occurred in Ohio on August 14, 2003, but Liberty had recommended 37 items that could be done by ComEd to strengthen their system further.

[8] Staff notes ComEd should be commended for having systems and procedures in place that prevented the July 2008 events from cascading to something more serious. Staff also notes it is equally important to prevent the initiating events, i.e. tree contacts.

[9] "When a tree contacts a power line it causes a short circuit, which is read by the line's relays as a ground fault. Direct physical contact is not necessary for a short circuit to occur. An electric arc can occur between a part of a tree and a nearby high-voltage conductor if a sufficient distance separating them is not maintained." Page 59, Chapter 4, U.S.-Canada Power System Outage Task Force, Final Report on the August 14th Blackout in the United States and Canada: Causes and Recommendations (April 2004) (Final Blackout Report).

discovery of the three cottonwood trees at least seven years old in a grove of perhaps one hundred trees growing directly under the transmission line pointed to programmatic failures in ComEd's annual transmission system walk down inspections and five year trim cycle. Here, Staff will provide a short summary of the details.

On July 6, 9, and 15, 2008, ComEd experienced instantaneous circuit breaker trips and successful recloses on its Kincaid-Latham-Blue Mound 345-kV electric transmission line (Line 2102)[10]. In each case, ComEd sent personnel to inspect specific sections of the line to determine the cause of the circuit breaker operations, but did not find the cause until an inspection on July 15th.

What the ComEd personnel found on that third inspection from a helicopter was a large grove of perhaps one hundred cottonwood trees growing in a swampy area beneath the transmission line on the south side of the Sangamon River (See Picture 1). ComEd crews trimmed the identified area on July 16th; the tallest trees were approximately 32 feet tall and showed seven growth rings, indicating seven years of age at the time ComEd cut them down. ComEd reported their matter to Reliability First Corporation[11] (RFC) on July 18th.

On July 30th, Staff learned that a vegetation contact incident was briefly mentioned on page 73 of the "Combined Notes To Consolidated Financial Statements" for Exelon, PECO, and ComEd. On July 31st, Staff sent ComEd a number of questions because ComEd's vegetation management failure was an apparent violation of ICC Administrative Code Part 305[12]. On August 7, 2008, ComEd responded that RFC, NERC, and FERC had responsibility[13] for the reliability of the interstate transmission grid and that ComEd's iterative process with RFC and NERC would be closed out in six

[10] During the August 14, 2003, blackout, one of three linchpin 345-kV lines that failed was the Star-South Canton 345-kV line that tripped and reclosed three times that day, electro trimming the trees in its ROW in the process, until it finally tripped and locked out. Page 63, Chapter 4, U.S.-Canada Power System Outage Task Force, Final Report on the August 14th Blackout in the United States and Canada: Causes and Recommendations (April 2004) (Final Blackout Report).

[11] On July 20, 2006, the North American Electric Reliability Corporation (NERC) was certified as the Electric Reliability Organization (ERO) in the United States, pursuant to Section 215 of the Federal Power Act of 2005. Included in this certification was a provision for the ERO to delegate authority for the purpose of proposing and enforcing reliability standards by entering into delegation agreements with regional entities. RFC is one of the eight approved Regional Entities in North America, under the NERC. RFC is a not-for-profit company incorporated in the State of Delaware, which began operations on January 1, 2006. RFC's mission is to preserve and enhance electric service reliability and security for the interconnected electric systems within the RFC geographic area. RFC's primary responsibilities include developing reliability standards and monitoring compliance to those reliability standards for all owners, operators and users of the bulk electric system and providing seasonal and long-term assessments of bulk electric system reliability within the Region. See: www.rfirst.org

[12] NESC Rule 218(A)(1) of the 2002 NESC Part 2 adopted by the Commission in Illinois Administrative Code 305.20 on June 15, 2003, states: "*Trees that may interfere with ungrounded supply conductors should be trimmed or removed. NOTE: Normal tree growth, the combined movement of trees and conductors under adverse weather conditions, voltage, and sagging of conductors at elevated temperatures are among the factors to be considered in determining the extent of trimming required.*"

[13] NERC Standard FAC-003-1(A)(4)(3) *This standard shall apply to all transmission lines operated at 200 kV and above and to any lower voltage lines designated by the RRO as critical to the reliability of the electric system in the region.*

months. ComEd stated it would keep Staff informed throughout the RFC process providing "the ICC with full details on the incident and the corrective actions that will be taken to prevent recurrence."[14]

Picture 1: Person standing next to Trees growing below Transmission Line

COMED'S VEGETATION MANAGEMENT PROGRAM: ComEd previously reported that it clears vegetation away from its electric transmission lines every five years by removing all vegetation that might grow or fall into the lines from the sides, the top, and underneath.[15] The objective is to ensure no tree interference with ComEd transmission lines except under very unusual circumstances such as a very strong wind blowing broken tree limbs into the line from outside the clearing zones[16]. ComEd also reported that it conducts annual foot patrols and aerial inspections of all transmission facilities.[17] Picture 2, below, is an aerial photograph of the section of line in question that is

[14] ComEd e-mail to ICC Staff on Thursday, August 7, 2008, 5:15PM.

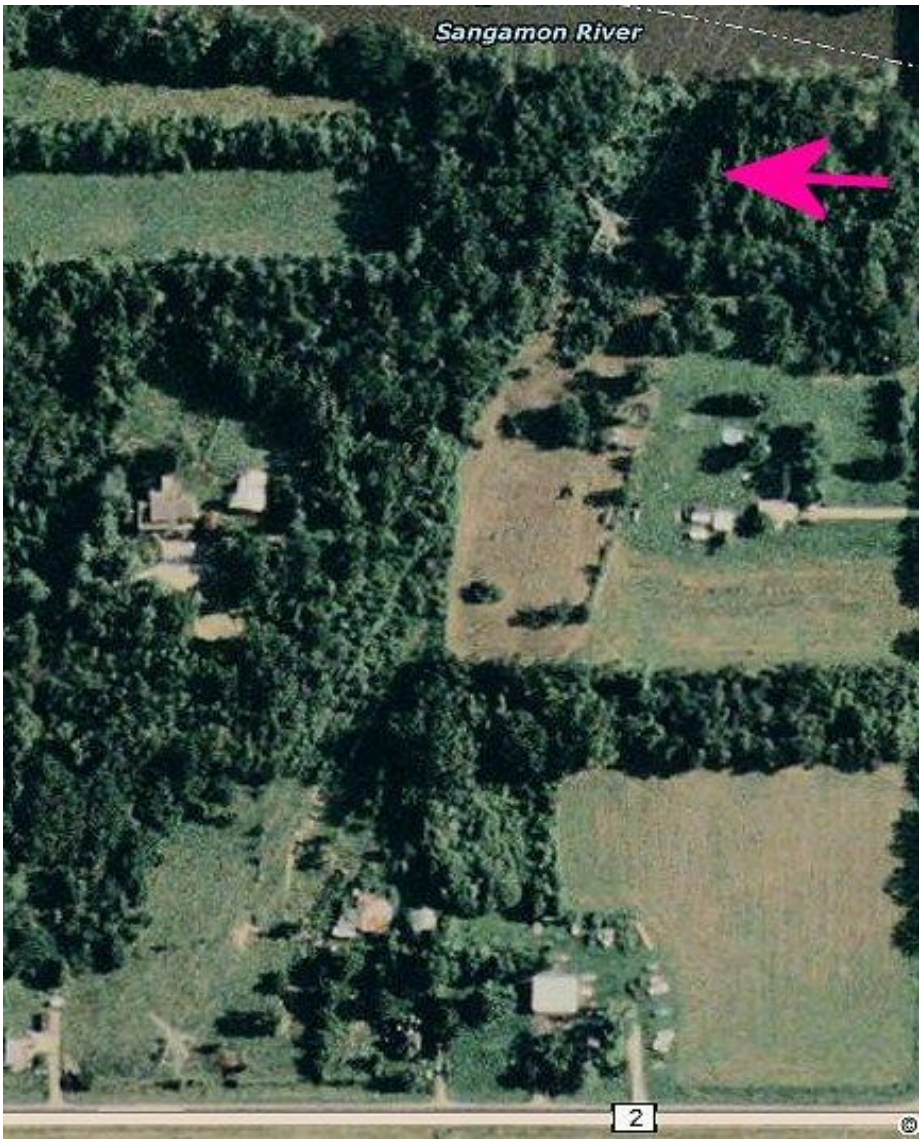
[15] Below the lines of a 345-kV the clearance should be greater than 30 feet and if clearances were 20 feet or less it would be cause for immediate "Fix-It-Now" (FIN) action – thus there should have been no tall seven year old trees (spanning two of ComEd's 5-year transmission system trim cycles), growing under the line. See ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound), Page 8, September 25, 2009.

[16] A typical right-of-way for a 345-kV electric transmission line is about 150 feet wide. ComEd guidelines VM-ED-P029 specify that for a nominal line voltage of 345kV and spans greater that 1,000 feet, the proposed VM side clearance measured horizontally from outside conductor to vegetation is 43 feet. This is the clearance that crews should trim to during scheduled cyclic maintenance.

[17] In its July 7, 2008, response to Staff data request ENG 4.2, ComEd stated in part: "…ComEd conducts an annual foot patrol inspection of all transmission facilities each year to ensure system safety and reliability with respect to vegetation, including tree to conductor clearance and dead or declining trees with the potential to fail and impact the facilities. Additionally, vegetation management and transmission engineering conduct an aerial inspection of the transmission system. … ComEd is currently on a 5 year maintenance cycle for the Trimming and Removal and Herbicide programs. …"

available from a number of free internet mapping services. While the date of the picture is unknown, it is recent enough (within the seven year period the trees were growing undisturbed) that the heavy growth in the 345-kV transmission right-of-way is apparent south of the Sangamon River.

Picture 2 – Aerial picture of part of transmission line pathway



ComEd hires contractors to perform its transmission line tree removal.[18] According to ComEd's policies[19], those contractors survey the transmission line rights-of-way, develop plans to perform the necessary clearing work, and complete the tree trimming and tree removal to provide the required clearance between the trees and the lines.

[18] Pages 5-19, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[19] Ibid.

Then, the contractors file reports with ComEd to explain what work was done and any work that remains to be done.

To make sure the tree removal contractors are performing the work to ComEd's standards, ComEd hires a quality assurance contactor[20] to perform inspections of the first contractor's tree removal work. When ComEd gets the reports from the tree removal contractor, the quality assurance contractor is sent to inspect the first contractor's work. If the quality assurance contractor's reports indicate that any work fails to meet ComEd's standards, the first contractor must revisit the site and correct its mistakes.

SITUATIONAL ASSESSMENT: According to ComEd's investigation, the tree removal contractor did not always provide ComEd with good work plans for the work necessary on each transmission line right-of-way. In the case of Line 2102, that contractor provided either poorly completed plans or, perhaps, no plans at all[21].

According to ComEd's investigative report the tree removal contractor may or may not have performed all the work detailed on its plans. The available evidence is not clear. What is clear is that the contractor did not remove the grove of trees growing under Line 2102 just south of the Sangamon River.[22]

The tree removal contractor did not always provide ComEd with timely completion reports on the work it performed on line rights-of way. In the case of Line 2102, the contractor did not provide a report for several months and, if fact, waited until after the July 2008 event before giving its report to ComEd.[23]

For reasons that are not clear to ComEd during their investigation, the quality assurance contractor completed its work quality inspection of the tree clearing work on Line 2102 before ComEd had authorized the inspection.[24] The contractor's inspection report indicated that the line clearing work done on Line 2102 met ComEd's standards except one area identified as needing additional work (not the area South of the Sangamon River where the tree contacts occurred).[25] From ComEd's RCI Report, it is clear that the quality assurance contractor could not have inspected the area south of the Sangamon River.

[20] Page 5, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[21] Pages 5-6, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[22] Pages 5-7, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[23] Page 6, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[24] Page 7, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[25] Page 7, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.

ComEd had dispatched ground patrols of Line 2102 on July 8th to investigate the July 6th incident and on July 10th, to investigate the July 9th incident. On the July 8th patrol, as ComEd later learned, vegetation around the base of tower 61 prevented the patrol from proceeding to a portion of Line 2102 and blocked the patrol's line-of-sight to towers 63 & 64.[26] However, the crew reported the patrol as completed with "nothing found" and "…did not provide or document any details about accessibility issues at the time of the patrol report."[27] During the July 10th patrol, in response to the July 9th incident, the crew identified an insulator with evidence of arcing and minor conductor damage. ComEd presumed these items to be the cause of the incidents on the 6th and 9th and scheduled repair work for early December 2008.

It was not until the July 15, 2008, incident and the subsequent aerial patrol's identification of the grove of trees between towers 63 & 64, that ComEd took notice of the failures of either the tree removal contractor or the quality assurance contractor or took any actions to correct the failures of either.

WHY COMED'S PROGRAM FAILED: The reason that trees grew into Line 2102 was that ComEd's tree removal and quality assurance contractors failed to perform their jobs and ComEd's personnel assigned to vegetation management on transmission line rights-of-way failed to ensure that ComEd's programs and policies were followed. If Staff's understanding of a ComEd presentation[28] about this issue is correct, ComEd had only one person[29] supervising all (tree removal clearing and quality assurance) work performed by all the contract personnel on all the transmission line rights-of way on the entire ComEd transmission system. The ComEd transmission system includes about 5,378 overhead transmission miles.[30]

Additionally, this single ComEd employee has been trying to keep up with a full-time office workload of managing the assignments and workloads of the various contractors while also bearing responsibility for field verification of tree removal and quality assurance contractor performance. This single transmission vegetation management employee is reported[31] to spend at least one day each week in the field.[3233] Staff

[26] The grove of trees where the contacts occurred was between towers 63 &64.
[27] Page 7, ComEd Root Cause Investigation (RCI) Report AR96038, Tree Contact on 345kV Line 2102 (Kincaid-Latham-Blue Mound, September 25, 2009.
[28] ComEd presentation to Staff October 10, 2008.
[29] ComEd commented January 28, 2009, that this work management is shared among 7 employees. In their February 11, 2009, response to a clarification data request ComEd indicated that 6 employees were 100% allocated to distribution and 1 employee was 100% allocated to transmission and that an additional employee was allocated equally to transmission & distribution for snow/grounds maintenance.
[30] ComEd data request response, Attachment ICC-1-20, "ComEd Vegetation Management Transmission Emergent Maintenance 2006-7 Survey Schedule As of July 26, 2008".
[31] ComEd presentation to Staff October 10, 2008.
[32] The ComEd transmission system stretches from the east side to the west side of Illinois and from the northern Illinois border to Peoria and Pawnee in central Illinois. The distances from Chicago to Quad Cities and Pawnee are about 170 miles (travel time of 3 hours one way) and 218 miles (travel time of 3 hours and 45 minutes one way), respectively. The magnitude of ComEd's system, at a total of 5,378 miles, would limit how much a single transmission vegetation management person would be able to inspect one day per week.

believes no single person could possibly perform that job satisfactorily: the job is just too big.

COMED'S SOLUTION: ComEd believes that it was not collecting the right kind of reports from the contractors and that it can solve the problem by developing and requiring the right kind of reports from the contractors as well as implementing GPS tracking of survey crews.

According to ComEd's root cause analysis report, the utility intends to make the following contractor reporting changes;

- Electronic documentation with GPS verification of annual surveys.
- Detailed electronic work plans for transmission lines scheduled for vegetation management work.
- Electronic documentation with GPS verification of quality surveys performed after vegetation management work is complete.
- More complete implementation of ComEd's transmission right-of-way vegetation management computer software.
- Procedure improvements for tracking easement issues.
- A study of technology available to help ComEd perform surveys of contractor work.
- Evaluation of internal and external staffing to meet regulatory requirements. (ComEd commented on 1-28-2009 that based upon their evaluation, ComEd is currently increasing its Transmission Vegetation Management staffing.)
- Revise program procedure documents and revise to agree with current practices.
- Rewrite procedures for ComEd line patrols after circuit breaker operations.

STAFF FOLLOW-UP: Staff will continue to follow this issue in the future as the company reports its progress in developing satisfactory changes to their programs and procedures to further minimize the likelihood of future transmission and distribution system contacts with vegetation.

Only ComEd's 345-kV and 765-kV transmission lines fall within the scope of NERC's Standard FAC-003-1[34] while ComEd's 2,770[35] miles of 138-kV transmission lines are (unless designated critical by RFC) outside NERC's scope. On the other hand, ComEd's entire transmission and distribution system is covered by many similar, if not

[33] ComEd commented January 28, 2009, that this work management is shared among 7 employees who conducted over 540 field audits of vegetation contractor crews in 2008. In their February 11, 2009, response to a clarification data request ComEd indicated that 6 employees were 100% allocated to distribution and 1 employee was 100% allocated to transmission and that an additional employee was allocated equally to transmission & distribution for snow/grounds maintenance.
[34] NERC Standard FAC-003-1(A)(4)(3) *This standard shall apply to all transmission lines operated at 200 kV and above and to any lower voltage lines designated by the RRO as critical to the reliability of the electric system in the region.*
[35] Page 3, Liberty Consulting Group, Report on a Focused Review of Commonwealth Edison's Transmission System Protection, December 16, 2003.

the same, ComEd procedures, practices, and management.[36] Similarly, reliability of service to Illinois electric customers[37], which is under the purview of the ICC, depends upon ComEd's entire transmission and distribution system.

Staff believes that this incident reflects potentially far reaching program deficiencies in ComEd's transmission & distribution vegetation management programs as well as other maintenance programs. A lack of depth or misallocation in staffing assignments or priorities impacted ComEd's comprehensive quality control and management oversight of vegetation management programs for transmission lines. The issue of applying insufficient resources and people to perform the necessary work and to assure quality control was addressed in a review of ComEd's substation[38] and distribution[39] maintenance programs. Regarding these transmission line issues, ComEd needs to make sure it has enough of its own people in the field doing quality checks to verify contractors' oral and written reports. Staff will look into the existence of similar staffing issues that may exist in ComEd's maintenance programs and ComEd's oversight of the distribution and substation system. Staff believes that comprehensive quality control and management oversight are fundamental to a good reliability program.

[36] ComEd data request responses: ICC-1-10a, ICC-1-10b, ICC-1-10c, ICC-1-10d, and ICC-1-10e (VM-ED-P011, VM-ED-P024, VM-ED-P025, VM-ED-P029, and VM-ED-P030)

[37] Illinois Public Utilities Act (220 ILCS 5/1-102) "*The General Assembly finds that the health, welfare and prosperity of all Illinois citizens require the provision of adequate, efficient, reliable, environmentally safe and least-cost public utility services …* "

[38] Chapter 11, Investigation of Commonwealth Edison's Transmission and Distribution Systems, Liberty Consulting Group, June 2000.

[39] These are very similar to the quality control and management issues noted in the Staff memorandum to the Commission "Liberty Verification of ComEd's 3rd Quarter 2002 Report" on February 3, 2003 which stated in part: "…Staff review of Liberty's report identified one material issue that has been discussed in the past and was identified by Liberty in the continuing verification of ComEd's inspection and maintenance on worst performing feeders. During the course of their verification this quarter, Liberty found that ComEd did not perform all the repairs that it had reported as performed on the year 2000 one percent worst performing feeders and that accuracy and consistency of the inspection reports continues to be problematic. What is important to note is that this quarter's verifications concentrated mainly on circuits that had repairs reported as completed and that were "checked" a second time by ComEd earlier in the year 2002 as a result of Liberty's findings on earlier samples of ComEd's year 2000 one percent worst performing feeders. The performance problems uncovered by Liberty on a sample of feeders, after ComEd had checked all year 2000 feeders a second time to be complete and accurate, were a surprise to ComEd management and resulted in personnel changes in some regions as well as ComEd's Executive Vice President of Energy Delivery Operations asking for a meeting with Staff on December 16, 2002, to specifically discuss what he intend to do in light of the latest Liberty findings. ComEd has found Liberty's actions to be valuable insights into areas where management controls are lacking. ComEd is planning to organize a group within their organization that would verify work done in distribution, substation, and tree trimming. …"